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Evaluation of Chemical Dust Palliatives for Helipads

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Evaluation of Chemical Dust Palliatives for Helipads

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Final report

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Prepared for U.S. Marine Corps Systems Command
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ABSTRACT: The ERDC was tasked by the U.S. Marine Corps Systems Command to develop expedient dust control systems for helipads for use in constructing and maintaining Forward Area Arming and Refueling Points. The project consisted of evaluating various chemical dust palliatives and application procedures during field tests. The products of this effort include equipment recommendations, palliative recommendations, and complete application guidance. Fifteen helipads were constructed at Marine Corps Air Station, Yuma, AZ, using commercial palliatives for dust abatement. Each chemical was applied using a topical (spray-on) treatment. Each helipad was subjected to multiple landings of UH-1, CH-53, CH-46, and AH-1 rotary-wing aircraft. The chemicals were evaluated on their ability to control dust and prevent foreign object damage. Each evaluation consisted of dust particle collection and soil property measurements. Pertinent conclusions from the testing conducted are noted, and recommendations for selecting dust abatement methods and materials are provided.

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Preface

The purpose of this report is to present results from a field experiment conducted for the evaluation of chemical dust palliatives for use on helipads. Dust abatement materials selected for use on helipads should effectively reduce dust concentrations during takeoff and landings and should pose little risk for foreign object damage to the aircraft. This report provides data for the following:

a. Evaluation of commercially available dust palliatives for mitigating dust on helipads.

b. Evaluation of commercially available hydroseeders for distributing dust palliatives.

c. Evaluation of the effect of palliative application rates on product performance.

Users of this report include the U.S. Marine Corps Systems Command (USMCSC) units charged with expedient helipad construction, and agencies assigned operations planning responsibilities.

The project described in this report is part of the Dust Abatement Program currently sponsored by Headquarters, USMCSC, 2200 Lester Street, Quantico, VA 22134-6050.

This publication was prepared by personnel of the U.S. Army Engineer Research and Development Center (ERDC), Geotechnical and Structures Laboratory (GSL), Vicksburg, MS. The findings and recommendations presented in this report are based upon field tests conducted at the Marine Corps Air Station, Yuma, AZ, from September to October 2005. The research team consisted of John F. Rushing, Vernon M. Moore, Jeb S. Tingle, Roosevelt Felix, Timothy McCaffrey, Quint Mason, and Ernest Woodward, Airfield and Pavements Branch (APB), GSL, and Tommy Carr and Alan Middleton, Information Technology Laboratory (ITL).

Messrs. Rushing, Moore, and Tingle prepared this publication under the supervision of Don R. Alexander, Chief, APB; Dr. Albert J. Bush III, Chief, Engineering Systems and Materials Division (ESMD); Dr. William P. Grogan, Deputy Director, GSL; and Dr. David W. Pittman, Director, GSL. Director of ITL was Dr. Jeffery P. Holland.

COL James R. Rowan was Commander and Executive Director ERDC. Dr. James R. Houston was Director.

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Executive Summary

The U.S. Army Engineer Research and Development Center was tasked by the U.S. Marine Corps Systems Command to develop dust control systems for helipads at Forward Area Arming and Refueling Points. The project consisted of a field evaluation of commercially available dust palliatives and application equipment for mitigating dust on helipads. The project was conducted near the Auxiliary II paved landing zone south of Marine Corps Air Station, Yuma, AZ. Fifteen helipads were constructed using commercially available dust palliatives placed with various construction equipment and techniques. Helipads were subjected to landings conducted with UH-1, CH-53, CH-46, and AH-1 rotary wing aircraft to evaluate the effectiveness of the dust palliatives. Ratings were assigned according to the ability of the product to reduce dust without potential for foreign object damage (FOD). Conclusions and recommendations as a result of this evaluation are listed below.

Conclusions

The following conclusions were derived from the application and testing of selected palliatives from September to October 2005:

a. Mobility was limited on the soft sand for several pieces of equipment. The motor grader had difficulty clearing the vegetation from the site because of poor traction. The High Mobility Multi-Wheeled Vehicle was unable to tow the hydroseeder at the site. The Medium Tactical Vehicle Replacement (MTVR) was suitable for pulling the hydroseeder, but the hydroseeder did not have enough ground clearance to prevent dragging loose soil.

b. Both of the hydroseeders used at the site provided excellent mixing of dust palliatives and dilution water by their mechanical agitation system.

c. Both hydroseeders provided two methods of applying liquid dust palliatives: a tower gun and a hand-held hose.

d. A 150-ft by 150-ft helipad cannot be treated with dust palliatives by either of the hydroseeders tested from a single location using the tower gun. The tower gun will spray distances of approximately 130 ft.

e. Each hydroseeder was capable of rapidly applying dust palliatives to the helipads. This type of equipment was very effective and could complete the process in as little as 20 to 30 min for a 150-ft by 150-ft helipad despite requiring repositioning due to effective spray distances.

f. Skid mounted hydroseeders transported with the MTVR are more effective for sites with off-road mobility concerns because of low ground clearance on the trailer mounted hydroseeders.

g. All of the dust palliatives could be sprayed with the hydroseeder. None had viscosities high enough to cause application problems.

h. Powdered Soiltac® immediately dissolved in water when placed in the tank of the hydroseeder. No problematic increases in the viscosity of the solution were noted.

i. The synthetic fluids were very effective at both 0.36 gallon per square yard (gsy) and 0.60 gsy application rates for mitigating dust on helipads.

j. Although effective, the synthetic fluids did not reach full penetration depth within the first day after application. These materials require several days to reach their maximum penetration for dust abatement.

k. The polymer emulsions did not reach sufficient penetration depths when applied at a 3:1 dilution ratio and a 0.60 gsy application rate. Lower application rates were also deemed unacceptable.

l. Penetration depths of less than 1 in. for the polymer emulsions were unable to resist breakup during helicopter landings. Broken layers of thin surface crust present potential danger for FOD to the aircraft.

m. Application rates of over 1 gsy may be required when using polymer emulsions for dust abatement on helipads to ensure adequate crust thickness and strength to resist breakup during helicopter landings.

n. The emulsified rubber performed similarly to the polymer emulsions. It would not be recommended at an application rate lower than 1 gsy for reasons associated with polymer emulsions.

o. The sodium chloride salt did not provide sufficient dust abatement during the evaluation. It was initially effective, but only for the first day of helicopter landings. The chloride salt is unable to retain moisture at humidity levels and temperatures present during the exercise, which were characteristic of arid climates.

p. The polysaccharide performed adequately during the evaluation. However, it was unable to resist breakup during landings and could pose some FOD problems.

q. The powdered polymer performed similarly to the polymer emulsions. It would have to be applied at rates greater than 1 gsy to provide acceptable penetration and dust abatement.

Recommendations

The following recommendations are given based upon the results of the field tests:

a. Hydroseeders are recommended for distributing dust palliatives on helipads. Limitations of the system noted in the text should be addressed when selecting systems for U.S. Marine Corps use.

b. Hydroseeders should have multiple application methods for distributing products. These should include and not be limited to a tower gun, hand-held hose, and a distribution bar.

c. Machine specifications for hydroseeders should meet or exceed the requirements in Table 17.

d. Both of the synthetic fluids evaluated are recommended for use on helipads at a minimum application rate of 0.36 gsy as a result of field data and observations made during the field evaluation. These materials are to be placed “neat” onto the soils using a topical application with no water for dilution.

e. Helicopter landings can proceed immediately after applying the synthetic fluids. However, it is recommended that they be applied at least 2 days in advance of landings for optimal performance. In contrast, it is recommended that helipads treated with polymer emulsions be allowed to cure or dry for at least 24 hr prior to helicopter landings.

f. Deteriorated areas on helipads treated with synthetic fluids should be repaired by reapplying the product at an application rate of 0.36 gsy to any areas of exposed untreated soil.

g. Polymer emulsions and emulsified rubber should not be used for mitigating dust on helipads using less than 1 gsy of a 3:1 dilution of water and dust palliative. Application rates lower than 1 gsy will potentially produce FOD damage to the aircraft upon landing.

h. Polysaccharides should be used for dust mitigation at a dilution ratio of 3:1 and an application rate of no less than 0.60 gsy. Higher application rates (1 gsy) may be necessary to improve performance.

i. Chloride salts are not recommended for dust abatement on helipads in arid environments.

j. Powdered Soiltac® may be used for dust abatement of 1.4 lb powder per gallon water. The application rate for this product should be greater than 1 gsy.

k. Powdered polymer refers only to Powdered Soiltac® evaluated during the field exercise. Many powdered polymers have a different chemical composition and are not recommended for use. Additionally, some types of powdered polymers cause extremely high viscosities to develop in the solution. These types of materials will have difficulty spraying from an application device. Thus, alternative powdered polymer products should be tested in similar fashion prior to procurement.

1 Introduction

Dust generation during rotary wing aircraft landings on untreated soil can produce brownout conditions that threaten personnel and increase maintenance requirements for the aircraft. Many methods for mitigating dust have been employed by the U.S. military during Operations Enduring Freedom and Iraqi Freedom, including chemical surface treatments, expedient lightweight mat solutions, and large stone cobble surfaces. Chemical dust palliatives have been used with varying degrees of success. The wide variety of chemical types and poor application guidance often prevents field engineers from choosing the best methods for site conditions and operation requirements. Well-documented research evaluations are needed to identify successful practices for applying chemical palliatives.

The Engineer Research and Development Center (ERDC) was tasked by the Marine Corps Systems Command (MCSC) to develop a dust control system for mitigating dust on expedient helipads. The project consisted of the evaluation of various dust palliatives and application procedures during field tests. The products of this research include equipment recommendations, palliative recommendations, and complete application guidance.

Objective

The primary objectives of this evaluation were to develop recommendations for the selection of dust palliatives and procedures for applying products on expeditionary helipads. This report provides data for the following:

a. Evaluation of commercially available dust palliatives for mitigating dust on helipads.

b. Evaluation of commercially available hydroseeders for distributing dust palliatives.

c. Evaluation of the effect of palliative application rates on product performance.

This report provides detailed descriptions of the testing location and procedures used for evaluating both palliatives and application equipment.

Scope

A dust control experiment was conducted from 25 September to 12 October 2005 at Marine Corps Air Station (MCAS), Yuma, AZ, in order to evaluate commercial dust palliatives for use on helipads. The evaluation was performed in conjunction with the Weapons and Tactics Instruction planned during that time. Rotary wing aircraft were provided by the Marine Aviation Weapons and Tactics Squadron 1 at MCAS Yuma. The test aircraft included the UH-1, CH-53, CH-46, and AH-1. Aircraft landings were used to evaluate fifteen helipads constructed with various chemical dust palliatives and application rates. Conclusions and recommendations resulting from this evaluation are provided in this report.

2 Background

Test Site Description

The field tests were conducted at MCAS, Yuma, AZ, on an area of open desert immediately north of the Auxiliary 2 paved landing zone. The area was graded using a model 143H Caterpillar motor grader (Photo 1) to remove all native vegetation. A John Deere 544J four-wheel drive bucket loader was used to backblade the loose sand to create a level and uniform surface prior to applying dust palliatives (Photo 2). Figure 1 provides a layout of the site and the location of the helipads.

Each helipad was 150- by 150-ft square with 100-ft untreated transition zones for separation. The soil was very loose after grading and back-blading, and general physical characteristics did not vary among helipad locations.

Dust Palliatives

The materials used in this evaluation are commercially available for purchase in quantities ranging from 5-gal containers to 5,000-gal tanker trucks. The cost of the products at the time of the experiment range from $0.40/gal to more than $30.00/gal depending on their chemical composition. Excluding synthetic fluids, most of the products are miscible with water and are intended to be diluted from their “as received” concentration.

Polymer emulsions

Envirotac II®, Soil~Sement®, and Soiltac® are classified as polymer emulsions. These products are generally vinyl acetate or acrylic-based copolymers suspended in an aqueous phase by surfactants. They typically consist of 40 to 50 percent solid particles by weight of emulsion. Once they are applied, the polymer particles begin to coalesce as the water evaporates from the system, leaving a soil-polymer matrix that prevents small dust particles from escaping the surface. The polymers used for dust control typically have excellent tensile and flexural strengths, adhesion to soil particles, and resistance to water.

Synthetic fluids

Durasoil® and Envirokleen® are synthetic organic fluids that are designed to be applied to a soil "as received." These fluids are not miscible with water and therefore are unable to be diluted. They consist of isoalkanes that do not dry or cure with time. The reworkable binder is ready for immediate use upon application and maintains effectiveness over extended periods of time.

Chloride salt

Dust Fyghter® is a solution of calcium, magnesium, and sodium chlorides. The solution typically contains approximately 38 percent chloride salt by weight. The material obtained for this test contained 40 percent chloride salt to reduce shipping volumes. This deliquescent material has been used for many years as a low-cost solution for dust problems. It maintains effectiveness by absorbing moisture from the air and binding soil particles together. Long-term efficiency of chloride salts are sometimes limited because the material is water-soluble and will leach from the soil with prolonged exposure to rainfall. Chloride salts are also known to be a highly corrosive material and will increase maintenance requirements for equipment operating on areas on which they have been sprayed.

Polysaccharide

Surtac® is a polysaccharide-based system composed of sugar, starch, and surfactants suspended in an aqueous solution. It is shipped in a concentrated form that may be diluted depending upon its intended use. Surtac® provides dust abatement by encapsulating soil particles and creating a binding network throughout the treated area. The binder is water soluble and reworkable. However, it is also susceptible to leaching from the soil with heavy rainfall.

Powdered polymer

Powdered Soiltac® is a water-soluble powder that provides dust abatement by encapsulating soil particles and creating a binding network throughout the treated area. The binder is water-soluble initially, but upon curing forms a non-soluble film.

Emulsified rubber

Helotron is an elastic, polymeric material suspended in water. It provides dust abatement through mechanisms similar to that of the polymer emulsions; however, the binder is much more flexible. The emulsion is approximately 50 percent solid material by weight.

Application Equipment

Two commercially available hydroseeders were used to distribute the dust palliatives onto the helipads. Both were transported using a 5-ton Medium Tactical Vehicle Replacement (MTVR) due to the soft soil site conditions. An Easy Lawn® C95 trailer-mounted unit was pulled using an adapted pintle hitch (Photos 3 and 4) to meet connection requirements of the MTVR. A Turfmaker® 800 hydroseeder was removed from its position on a trailer and placed onto the bed of the MTVR for transportation (Photo 5). The Turfmaker® model offers the option of being used as either a trailer-mounted unit or a skid-mounted unit. Specifications for the two hydroseeders are located in Table 1.

Test Site Characterization

Several evaluation tools were used to determine the effectiveness of each dust abatement method on the constructed helipads. Soil classification and in situ property measurements allowed researchers to understand the mechanisms by which the dust palliatives worked. Dust collection systems were used to quantify the amount of material dislodged from the helipad upon aircraft landings. Overall recommendations were based upon the data obtained and the visually perceived mitigation of dust.

Table 1
Hydroseeder Specifications

	Easy Lawn® C95	Turfmaker® 800
Tank Capacity, gal	900	800
Empty Weight, lb	5,180	2,500
Loaded Weight, lb	14,300	8,200
Width, in.	91.5	56
Length, in.	183	153
Height, in.	111	60
Engine	John Deere 49 HP diesel	Vanguard 16 HP gasoline
Pump	4 in.x 3 in. Centrifugal HPV7H, 110 psi/620 gpm max	Positive Displacement
Empty Time		
Hose	22	16
Tower	9	6
Agitation	Mechanical	Mechanical
Point of Contact	Bob Lisle Easy Lawn, Inc. 9599 Nanticoke Business Park Drive Greenwood, DE 19950	Jim Lincoln Turfmaker Corporation 1-800-551-2304 jaslincoln@turfmaker.com

Soil classification

Soil samples were collected from various test helipads and subjected to a sieve analysis and Atterberg limit tests. The gradation curve for the soil is plotted in Figure 2. The soil was classified as a poorly graded sand with silt (SP-SM) according to the Unified Soil Classification System.

Nuclear density and moisture measurements

A Troxler® 3430 nuclear gauge was used to collect density and moisture data in the center of each helipad prior to palliative application and after the final day of aircraft landings (Photo 6). The gauge contains two radioactive sources: Cesium-137 for density measurement and Americium-241:Beryllium for determining moisture content. Density measurements were taken in the 6-in. direct transmission mode according to American Society for Testing and Materials (ASTM) D2922. Moisture contents were obtained using procedures outlined in ASTM D3017.

Near-surface shear strength measurements

A Geonor H-60 vane shear device was used to measure shear strength of the near-surface soil in order to determine the effect of the dust palliatives on the surface soil strength (Photo 7). The 25.4 mm × 50.8 mm vane was used for all tests. The procedure involved pressing the vane vertically into the soil until the top of the vane was even with the soil surface. With the graduated scale reading set at zero, the device was rotated until the soil provided no resistance to the internal spring. The reading on the graduated scale was recorded as the in situ strength. Remolded strengths were taken by zeroing the device and rotating it multiple times in the disturbed soil and recording the location of the dial on the scale. All readings were multiplied by 0.5 to adjust for using the large vane as recommended by the manufacturer.

Dynamic cone penetrometer (DCP) measurements

DCP tests were conducted according to the procedure described by ASTM D6951. The DCP had a 60-deg cone with a base diameter of 0.79 in. (41.4 mm). The test procedure involved placing the DCP cone point on the surface and recording a baseline measurement to the nearest 5 mm. The 10.1-lb hammer was then raised and dropped 22.6 in. (57.4 cm) onto an anvil, which drove the penetrometer rod and cone into the soil. Depth of the cone penetration measurements and number of hammer blows were recorded approximately every inch (25 mm) or whenever any noticeable change in penetration rate occurred. A DCP strength index in terms of penetration per hammer blow was calculated for each measurement interval. The DCP index was then converted to California Bearing Ratio (CBR) percentage using the correlation CBR = 292/(DCP*2)1.12 where DCP is in mm/blow. Multiplying the DCP value by 2 correlates the 10.1-lb hammer to the 17.6-lb hammer for which the relationship was developed. The CBR value ranges from 0 to 100 percent and provides an index of relative soil strength with depth. DCP data for this report were processed using a Microsoft Excel spreadsheet. Photo 8 illustrates the use of the DCP on an untreated helipad.

Rotary Wing Aircraft Testing

Selected helipads were subjected to landings with UH-1, CH-53, CH-46, and AH-1 rotary wing aircraft. The landing sequence consisted of one “dust off” procedure and three landings. The “dust off” served to remove any accumulated surface material due to testing adjacent helipads before evaluating the products. Dust particle collection and visual rankings were based on the three subsequent landings and departures. Aircraft characteristics are listed in Table 2.

Table 2
Aircraft Characteristics

	Length (ft)	Height (ft)	Rotor Diameter (ft)	Min Takeoff Weight (lb)	Max Takeoff Weight (lb)
UH-1	57.3	14.9	48.0	6,000	10,500
CH-53	99.0	28.3	79.0	35,220	69,750
CH-46	84.3	16.7	51.0	14,770	24,300
AH-1	45.5	13.5	48.0	10,220	14,750

Dust particle sampling

The dust particle collection system consisted of two dust collectors placed along the perimeter of the helipad on two adjacent sides. Each collector consisted of a cloth filter placed over a wire mesh screen through which a vacuum pressure was drawn using an electric vacuum pump (Photo 9). The two collectors were placed on the downwind sides of the helipad. After aircraft landings, the filters were removed, weighed, and compared to their initial weights to determine the amount of material collected.

Visual performance rating

During each set of aircraft landings, the pilot was asked to rank the helipads based on the reduction in dust during approach and takeoff. The perception of the pilot was considered to be more valid than that of the ground crew because of significant generation of dust from the perimeter of the helipads obstructing the view of the ground crew. These rankings served to validate and supplement physical data collected during the evaluation.

Initial Site Characterization

The nuclear gauge, Geonor vane shear, and the DCP were used to collect in situ soil property data prior to application of dust palliatives. These data were compared to data collected after palliative application to identify changes in strength or moisture content of the soil. The results from the initial data collection are shown in Tables 3 through 5.

Table 3
Pretreatment Moisture and Density Data

Helipad	Wet Density (lb/ft^3)	Dry Density (lb/ft^3)	Moisture (lb/ft^3)	Moisture (%)
1	108.8	108.5	0.3	0.3
2	111.2	110.6	0.6	0.5
3	108.1	107.8	0.3	0.3
4	106.5	106.2	0.3	0.3
5	109.9	109.3	0.5	0.5
6	112.5	112.1	0.4	0.4
7	106.3	105.4	0.9	0.9
8	109.7	109.3	0.4	0.4
9	108.4	108.1	0.3	0.3
10	108.5	108.3	0.2	0.2
11	110.1	109.6	0.5	0.5
12	108.2	107.0	1.2	1.2
13	109.0	109.1	0.2	0.2
14				
15				
Average	109.0	108.6	0.5	0.5

Table 4
Pretreatment Geonor Vane Shear Near Surface Strength

Helipad	Vane Size	Remolded Shear Strength, kPa			Average Remolded (kPa)
		Remolded 1	Remolded 2	Remolded 3	
1	Large	7.0	6.0	6.0	6.3
2	Large	6.0	6.0	5.5	5.8
3	Large	6.0	5.0	5.0	5.3
4	Large	7.0	6.0	6.0	6.3
5	Large	6.0	6.0	6.0	6.0
6	Large	7.5	6.0	6.0	6.5
7	Large	8.0	7.0	7.5	7.5
8	Large	8.0	8.5	8.5	8.3
9	Large	6.0	7.0	7.0	6.7
10	Large	8.0	7.0	8.0	7.7
11	Large	5.0	5.0	5.0	5.0
12	Large	6.0	6.0	6.0	6.0
13	Large	6.0	5.0	6.0	5.7
14	Large	4.0	4.5	5.0	4.5
15	Large	4.0	5.0	4.0	4.3

Table 5
Pretreatment Dynamic Cone Penetrometer Data

Helipad	Depth (in.)	CBR (%)	Depth (in.)	CBR (%)
1	surface	0 - 2	6 - 24	6 - 9
2	surface	0 - 2	6 - 24	10 - 11
3	surface	0 - 2	6 - 24	6 - 11
4	surface	0 - 2	6 - 24	8 - 11
5	surface	0 - 2	6 - 24	8 - 10
6	surface	0 - 2	6 - 24	10 - 11
7	surface	0 - 2	6 - 24	10 - 11
8	surface	0 - 2	6 - 24	6 - 10
9	surface	0 - 2	6 - 24	6 - 10
10	surface	0 - 2	6 - 24	5 - 8
11	surface	0 - 2	6 - 24	5 - 10
12	surface	0 - 2	6 - 24	8 - 10
13	surface	0 - 2	6 - 24	8 - 10
14	surface	0 - 2	6 - 24	9 - 11
15	surface	0 - 2	6 - 24	7 - 10

3 Helipad Construction

Experiment Design

The dust palliative evaluation was designed to investigate product performance, to evaluate product application rates, and to identify the most effective application procedure for material placement. Dust palliatives were applied using either a manually controlled hose or with a tower gun mounted on top of a hydroseeder. All applications were placed topically. Different application rates were used for selected products in order to identify the minimum material quantity necessary for the desired performance. Landings with UH-1, CH-53, CH-46, and AH-1 aircraft allowed researchers to evaluate the products for a range of aircraft weights and rotor diameters.

Helipad Construction

The ERDC leased or supplied the construction equipment used during the evaluation. Preliminary site preparation was completed using a Caterpillar® model 143H motor grader and a John Deere® 544J bucket loader. The motor grader was used to clear the native vegetation from the site. The bucket loader was used to level the soil and to create a smooth surface for product application. Dust palliatives were placed using either an Easy Lawn® model C95 or a Turfmaker® 800 model hydroseeder. Each machine was equipped with both hose and tower gun application equipment. Dust palliatives were diluted (when necessary) inside the hydroseeder using mechanical agitation. Other equipment included a Caterpillar® model TH460B forklift for loading/unloading materials (Photo 10), three Polaris Ranger utility carts for transporting instrumentation, a 4,000-gal water truck for storing/retrieving dilution water, and a 7-ton MTVR for transporting the hydroseeder.

The following paragraphs detail the chemicals and procedures used for constructing each of the helipads. The total product amounts for each helipad are given in Table 6. Product application rates are given in gallons per square yard (gsy).

Envirotac II® was not placed on a helipad during the evaluation. The dust palliative was purchased from Environmental Products and Applications, Inc.

Table 6 Dust Palliative Application Quantities by Helipad					
Product	Helipad	Additive Amounts, gal			Application Rate (gsy)
		Product	Water	Total	
DC 100®	1	225	675	900	0.36
Powdered Soiltac®	2	2,200 lb	1,500	1,500	0.60
Soil~Sement®	3	375	1,125	1,500	0.60
Soiltac®	4	375	1,125	1,500	0.60
Surtac®	5	375	1,125	1,500	0.60
Envirokleen®	6	1,500	0	1,500	0.60
Envirokleen®	7	900	0	900	0.36
Powdered Soiltac®	8	1,500 lb	900	900	0.36
Soiltac®	9	225	675	900	0.36
Helotron	10	375	1,125	1,500	0.60
Helotron	11	225	575	800	0.32
Dust Fyghter®	12	1,375	125	1,500	0.60
Durasoil®	13	900	0	900	0.36
Surtac®	14	225	675	900	0.36
Untreated	15	0	0	0	

and delivered to the testing site. The material in the containers that the ERDC received had coagulated and was unusable because it would not flow through the transfer pump (Photo 11). The product appeared to have bacterial contamination as evidenced by a putrid odor.

Helipad 1

The first helipad was sprayed with 0.36 gsy of a 3:1 water:DC 100® solution. The DC 100® (225 gal) and water (675 gal) were placed in the Easy Lawn® hydroseeder and mixed for 5 min. The product was applied using the tower gun, spraying half of the helipad from a single location before relocating to the opposite side. Two men completed the process (including filling the tank and spraying) in 17 min.

Helipad 2

The second helipad was constructed using Powdered Soiltac®. Quantities of the powder were chosen to replicate active ingredients found in the liquid Soiltac®. Twenty-two bags (1,100 lb) of the powder were mixed with water in the Easy Lawn® hydroseeder for a total of 750 gal of product (Photo 12). The powder immediately dissolved in the water. The solution was mixed for 5 min and then applied to half of the helipad using the hand-held hose. The other half of the helipad was sprayed with an additional 750 gal of an identical solution to complete the helipad with a 0.60 gsy application rate. Some puddling of the product was observed during application (Photo 13). The process took four men a total of 53 min (including filling and mixing).

Helipad 3

The third helipad was sprayed with a 0.60 gsy mixture of water and Soil~Sement® (3:1) using the Turfmaker® hydroseeder. Half of the mixture (750 gal) was placed into the tank of the hydroseeder and applied to half of the helipad using the tower gun. The process was repeated to complete the helipad. The helipad required five men a total of 57 min to construct.

Helipad 4

The fourth helipad was treated with 1,500 gal of a 3:1 mixture of water and Soiltac®. The application was completed using the Turfmaker® hydroseeder. Half of the product was distributed with the tower gun over half of the helipad. After refilling, the remaining product was placed with the hand-held hose. Total application time was 58 min using four men.

Helipad 5

The fifth helipad was constructed using Surtac®. Two tanks of the product were applied with the Easy Lawn® hydroseeder for a total of 1,500 gal (0.60 gsy, 3:1 water:Surtac®). One half was sprayed with the hand-held hose (Photo 14), and the other was placed using the tower gun. The procedure required four men a total of 58 min (including filling time).

Helipad 6

The sixth helipad was sprayed with 0.60 gsy of Envirokleen®. This product was not diluted with water. Half (750 gal) was placed in the Easy Lawn® hydroseeder and applied using the hand-held hose. The process was repeated to spray the remaining product (750 gal). Three men completed the helipad in 51 min. The product had penetrated approximately 0.75 in. into the soil 1 hr after application. The location of the treated soil was very evident as a result of the color of the soil changing.

Helipad 7

The seventh helipad was constructed in the same manner as the previous helipad with a lower application rate. A total of 900 gal (0.36 gsy) of Envirokleen® was sprayed from the hand-held hose using one filling of the Easy Lawn® hydroseeder. The product was sprayed from two separate locations on opposite sides of the helipad (half on each side). The procedure required four men 28 min to complete. Penetration depths were approximately 0.38 in. after both 1 and 15 hr. The treated soil appeared very dark compared with the untreated surrounding soil.

Helipad 8

The eighth helipad was also treated with Powdered Soiltac®. This helipad was constructed similarly to helipad 2 but with a lower application rate (0.36 gsy). Water and 30 bags (1,500 lb) of powder were placed in the Easy Lawn® hydroseeder (900 gal total) and mixed for 5 min. The solution was sprayed onto the helipad using the tower gun. The helipad was treated in two separate halves, spraying from two independent locations directly across from one another. Total application time for the helipad was 29 min for two men, including mixing the powder. The product did not appear to penetrate the soil as rapidly as the polymer emulsions.

Helipad 9

The ninth helipad was constructed using 0.36 gsy of a 3:1 water:Soiltac® mixture. A total of 900 gal was applied to the helipad using the Easy Lawn® hydroseeder. Spraying was completed using the tower gun from two locations on opposite sides of the helipad. The process took two men 27 min to complete.

Helipad 10

Helipad 10 consisted of a 0.60 gsy application of a 3:1 mixture of water and Helotron. The product was sprayed using the hand-held hose on the Turfmaker® hydroseeder. A total of 1,500 gal of the mixture was applied using two full tanks. One half of the helipad could be covered with a full load in the Turfmaker®. Applying the product required five men a total of 57 min.

Helipad 11

The eleventh helipad was also treated with Helotron. Construction of the helipad was identical to helipad 10 but at a lower application rate (0.32 gsy). Eight hundred gallons of a 2.5:1 mixture of water and Helotron was applied using the hand-held hose on the Turfmaker® hydroseeder. Spraying was performed from two locations on opposite sides of the helipad. Five men required 45 min to complete the process.

Helipad 12

The twelfth helipad was sprayed with Dust Fyghter®. Here, 1,375 gal of Dust Fyghter® was mixed with 125 gal water in two fillings of the Easy Lawn® hydroseeder. The extra water added to the solution reduced the chloride content from its concentrated form to approximately 37 percent by weight. The product was applied to the helipad using the tower gun. One tank (750 gal) was sprayed onto each half of the helipad. The process required two men 57 min to complete. Personnel applying the product noted irritation caused by overspray from the solution.

Helipad 13

Helipad 13 was sprayed with 0.36 gsy of Durasoil®. Nine hundred gallons of Durasoil® was placed in the Easy Lawn® hydroseeder and distributed over the helipad using the hand-held hose from two locations on opposite sides of the helipad. Four men completed the application process in 46 min.

Helipad 14

Helipad 14 was treated with 0.36 gsy of a 3:1 mixture of water and Surtac®. A total of 675 gal water and 225 gal Surtac® were mixed in the Easy Lawn® hydroseeder for 5 min. The mixture was then applied to the helipad using the tower gun. Spraying was performed from two locations on opposite sides of the helipad. The process required two men a total of 24 min.

Helipad 15

Helipad 15 was not treated with a dust palliative. The site was marked with fluorescent flagging on the corners and served as a control helipad for performance comparison. Construction consisted of back-blading the graded sand until a smooth, level surface was obtained.

4 Dust Palliative Evaluation

Military operations are often constrained by time and equipment needs when occurring in remote locations. It is imperative that materials and processes chosen for dust suppression make optimum use of the resources available to the personnel involved. The procedures and materials selected for mitigating dust on helicopter landing areas should effectively prevent "brownout" conditions but should not burden operations by requiring large quantities of material or cumbersome equipment. This evaluation was designed to identify processes, equipment, materials, and application rates that would sufficiently meet the requirements for minimizing dust with the least logistical requirements.

Soil Data

The nuclear density gauge and vane shear devices were used to collect information about the soil properties after the dust palliatives were applied. These data were compared to initial testing results to determine the effect that the dust palliatives had on the soil. DCP data were not recorded after product placement because the dust palliatives only affected the soil properties near the ground surface, and this region is not applicable to DCP tests in loose sands.

Nuclear density gauge post application data

Table 7 displays the results from the nuclear density gauge 6 days after applying dust palliatives.

The average dry density and moisture content for the soil was 106.6 pcf and 0.6 percent, respectively. Variations in the data among sites were not significantly different and were likely influenced more by local variations within the helipad than by actual differences throughout the testing area. The post test nuclear guage data show a 2.0 pcf drop in the average dry density and a 0.1% increase in the average moisture content compared to pre-construction values. The slight decrease in density could not be attributed to specific products, and the slight increase in moisture is reasonable given the moisture added during product application and the 6 days available for infiltration and evapotranspiration.

Vane shear post application data

The Geonor vane shear device was used to obtain in situ and remolded shear strengths of the surface soil 6 days after palliative application. Table 8 lists the results from this testing.

Table 7
Post Application Moisture and Density Data

Helipad	Wet Density (pcf)	Dry Density (pcf)	Moisture (pcf)	Moisture (%)
1	111.2	110.6	0.5	0.5
2	109.1	108.4	0.7	0.6
3	108.0	107.5	0.5	0.5
4	109.6	108.5	1.1	1.0
5	106.7	106.1	0.5	0.5
6	107.3	105.8	1.5	1.4
7	107.4	106.6	0.8	0.7
8	107.0	106.7	0.3	0.3
9	101.5	101.3	0.2	0.2
10	107.3	106.9	0.4	0.4
11	104.8	104.6	0.2	0.2
12	105.6	104.6	1.0	1.0
13	105.8	105.0	0.8	0.7
14	108.0	107.6	0.4	0.4
15	109.3	108.9	0.4	0.4
Average	107.2	106.6	0.6	0.6

Table 8
Post Application Geonor Vane Shear Data

Helipad	Vane Size	In Situ Strength (kPa)	Remolded Shear Strength (kPa)		Average Remolded (kPa)
			Remolded 1	Remolded 2	
1	Large	20.0	3.0	3.5	3.3
2	Large	60.0	4.5	5.0	4.8
3	Large	61.0	4.0	4.5	4.3
4	Large	46.0	3.0	4.0	3.5
5	Large	44.0	4.0	4.5	4.3
6	Large	7.0	4.5	5.0	4.8
7	Large	5.5	3.5	4.0	3.8
8	Large	20.0	2.0	2.0	2.0
9	Large	36.0	5.0	4.5	4.8
10	Large	19.0	3.5	4.0	3.8
11	Large	8.0	3.0	3.5	3.3
12	Large	3.0	3.0	3.5	3.3
13	Large	5.0	4.0	4.5	4.3
14	Large	11.0	4.0	5.0	4.5
15	Large	4.0	4.0	5.0	4.5
Range of values:		4 - 61	2 - 5	2 - 5	2 - 5

The data from post application shear testing indicate significant increases in the in situ shear strength for several products. The film forming products (polymer emulsions, powdered polymer, emulsified rubber) all had values much higher than those obtained on the untreated soil. These strength values ranged from five to fifteen times the strength of the untreated soil. The magnitude of the increase was also proportional to the application rate used on the helipad. Helipads treated with 0.60 gsy of these products had higher in situ shear strengths than those treated with 0.36 gsy of the same product.

The non-film forming products also showed some increase in the in situ shear strength. The synthetic fluids were slightly stronger than the untreated soil, while the polysaccharides provided more significant increases. These increases were also related to the application rate used on the helipads.

Palliative penetration depth

Measurements were taken at four locations on each helipad to measure the depth of penetration of dust palliatives 6 days after application. Data are presented in Table 9.

Table 9
Penetration Depth of Dust Palliatives

Helipad	Product	Application Rate (gsy)	Crust Thickness (in.)				Average Crust (in.)
			1	2	3	4	
1	DC 100®	0.36	0.50	0.25	0.50	0.38	0.41
2	Powdered Soiltac®	0.60	0.38	0.25	0.25	0.25	0.28
3	Soil~Sement®	0.60	0.50	0.38	0.50	0.38	0.44
4	Soiltac®	0.60	0.63	0.50	0.50	0.50	0.53
5	Surtac®	0.60	0.50	0.25	0.25	0.25	0.31
6	Envirokleen®	0.60	1.50	1.88	1.75	1.75	1.72
7	Envirokleen®	0.36	1.13	1.50	1.25	1.25	1.28
8	Powdered Soiltac®	0.36	0.19	0.25	0.19	0.19	0.20
9	Soiltac®	0.36	0.19	0.25	0.31	0.25	0.25
10	Helotron	0.60	0.31	0.38	0.50	0.63	0.45
11	Helotron	0.36	0.19	0.25	0.19	0.19	0.20
12	Dust Fyghter®	0.60	0.63	0.88	0.75	1.50	0.94
13	Durasoil®	0.36	1.25	1.25	0.88	1.00	1.09
14	Surtac®	0.36	0.13	0.13	0.19	0.19	0.16

The depth of penetration for the film forming products was lower than that of other palliatives. These materials adhered to soil particles at the surface of the soil and did not penetrate well.

The polymer emulsions had relatively the same penetration for a given application rate. In general, polymer emulsions applied at 0.36 gsy formed a 0.25-in. crust on the soil surface. Polymer emulsions applied at 0.60 gsy formed a 0.5-in. crust on the surface. Heavier application rates would be needed to support the weight of the aircraft on this low strength soil without the landing gear breaking through the crust.

The powdered polymer had the thinnest surface crust of all products. The viscosity of this product was observed to be higher than the emulsified polymers. Also noted was some puddling of the product on the soil surface during application. Its resistance to flow through the soil voids allowed the material to dry and stiffen before reaching penetration depths similar to other materials.

The polysaccharide had penetration depths lower than the polymer emulsions but deeper than the powdered polymer. This product also has a higher viscosity than the emulsified products because it is in the form of a solution with a high concentration of dissolved solids.

The emulsified rubber penetrated to depths similar to the polymer emulsions. The amount of solid material in the emulsion is similar to that of the polymer emulsions with similar viscosity, so this result was expected.

The synthetic fluids penetrated deeper than any of the other products. The penetration depths were influenced by the application rate at which they were applied. These materials have a viscosity significantly greater than the emulsified products, but do not form a film and will continue to seep through the soil. Initial penetrations depths were approximately 0.50 in. after the first day, but the synthetic fluids progressively work their way through the soil.

Dust Collection Data

Rotary wing aircraft landings took place 3 - 7 October 2005. Due to limitations concerning aircraft availability, only selected helipads were evaluated with a particular airframe. Table 10 lists the individual aircraft and landing information. Helipads were evaluated during landings by the particulate matter collected by the dust collection system as well as by the visually perceived reduction in dust noted by both the pilot and ground crew. Additional data were obtained upon completion of all testing including collection of soil property data.

Table 10
Aircraft Traffic Summary

Aircraft	Date	Helipads Evaluated
UH-1	3-Oct-2005	15, 5, 3, 12, 2, 6, 4
CH-53	5-Oct-2005	15, 13, 7, 12, 6
CH-46	6-Oct-2005	15, 13, 7, 5, 6, 10, 12
AH-1	7-Oct-2005	15, 13, 7, 5, 6, 14

UH-1 rotary wing aircraft testing

The evaluation of dust palliatives for the UH-1 aircraft took place from 1430 to 1830 on 3 October 2005. The first helipad tested was the untreated helipad to allow the pilot and ground crew to have a relative comparison for the effectiveness of the dust palliatives. Pilot rankings and dust collection data for the UH-1 traffic series are located in Table 11. Photos 15 through 24 illustrate the relative performance of the dust palliatives during landings.

Table 11
UH-1 Dust Collection Data

Product	Helipad	Initial Filter Weight (g)		Final Filter Weight (g)		Dust Collected (g)			Pilot Ranking
		Northwest	Northeast	Northwest	Northeast	Northwest	Northeast	Total	
Envirokleen®	6	12.786	13.941	13.757	14.201	0.971	0.260	1.231	1
Dust Fyghter®	12	13.885	15.545	14.592	15.930	0.707	0.385	1.092	2
Surtac®	5	12.984	11.493	13.658	11.800	0.674	0.307	0.981	3
Soil~Sement®	3	12.587	13.860	13.853	14.640	0.996	0.780	1.776	4
Powdered Soiltac®	2	14.719	12.397	15.293	12.578	0.574	0.181	0.755	5
Soiltac®*	4	14.227	12.438	15.151	23.403	0.924	10.965	11.889	6
Control	15	12.932	13.136	19.639	15.401	6.707	2.265	8.972	7

* Dust collector on northeast side of helipad 4 fell over during testing sequence and collected soil from the ground onto the filter

Dust collection data indicate excellent performance by all palliatives compared to the untreated helipad. Dust concentrations were reduced by at least 80 percent on each of the helipads tested. Overall dust reduction was inferred on Helipad 4 from the amount of soil collected by the collector on the northwest side of the helipad. The dust collector on the northeast side of the helipad fell during the landing sequence, allowing soil from the ground surface to be pulled into the filter and recorded.

Data collected from the dust collectors on the northeast sides of the helipads were more consistent with the pilot's rankings than those on the northwest sides. Inconsistent data from the dust collectors on the northwest sides of the helipads may have been influenced by the maneuver pattern during landings. The pilot approached the northwest sides of the helipads during landings and generated a high concentration of dust originating from the soil adjacent to the helipad. This dust remained in the helicopter's rotor wash as it entered the location above the treated soil but quickly dissipated as the aircraft approached the center of the treated helipad. The soil particles collected on the northeast sides of the helipads was more likely to originate from the treated area than the soil particles collected on the northwest sides of the helipads.

The pilot operating the UH-1 aircraft indicated helipad 6 as the most effective of the helipads tested at dust reduction. Minimal dust was observed during the landing sequence, and the pilot maintained complete visibility with the ground. Helipad 12 was slightly worse than 6 but still very effective. The soil color was distinctly different from untreated areas, and little dust was produced during landing. Helipad 5 was considered effective, but some minor foreign object damage (FOD) was produced, exposing untreated soil that generated minimal dust. Helipads 3, 2, and 4 were generally equally effective at mitigating dust during landings. However, each of these helipads produced significant quantities of FOD during the landing sequence. Large sheets (greater than 1 sq ft) of bound soil became airborne on each of these helipads. Some locations experienced "peeling" of the surface crust, revealing areas of untreated soil greater than 10 sq ft (Photos 22 through 24). Lighter applications of the same products were expected to produce similar or worse conditions and were not tested to prevent damage to the aircraft. Thus, helipads 8, 9, and 14 were not tested due to FOD potential.

CH-53 rotary wing aircraft testing

The evaluation of dust palliatives for the CH-53 aircraft took place from 0900 to 1000 on 5 October 2005. The untreated helipad (helipad 15) was tested first to allow the pilot and ground crew to observe the native conditions before comparing product performance. Pilot rankings and dust collection data are located in Table 12. Photos 25 through 29 provide relative visual performance during landings.

Table 12
CH-53 Dust Collection Data

Product	Helipad	Initial Filter Weight (g)		Final Filter Weight (g)		Dust Collected (g)			Pilot Ranking
		Southeast	Southwest	Southeast	Southwest	Southeast	Southwest	Total	
Durasoil®	13	14.976	16.400	18.107	18.061	3.131	1.666	4.792	1
Envirokleen® (0.36 gsy)*	7	15.152	14.263	36.440	16.958	21.228	2.695	23.983	2
Envirokleen® (0.60 gsy)	6	13.496	12.973	14.729	15.997	1.233	3.024	4.257	3
Dust Fyghter®	12	14.528	13.981	15.795	19.646	1.267	5.665	6.932	4
Control	15	15.809	14.599	19.965	25.639	4.156	11.040	15.196	5

* Dust collector on southeast side of helipad 7 fell over during testing sequence and collected soil from the ground onto the filter

The data indicate that each of the dust palliatives was relatively effective compared to the untreated control helipad, and they reduced the concentration of dust particles in the air from approximately 50 to 75 percent. The overall performance of helipad 7 is inferred from the particles collected by the southwest dust collector. The collector on the southeast side was blown over during the landing sequence. This caused the vacuum to pull soil from the ground and greatly enhance the amount of soil trapped in the filter.

Data from the dust collectors on the southwest sides of the helipads are more consistent with the pilot's observations of palliative performance than those on the southeast sides. A possible explanation for this phenomenon is the effect of the pilot's approach on dust generation and collection. The landings were preceded by a forward approach that passed over the dust collectors on the southeast side (Photo 30). This type of movement caused untreated soil adjacent to the helipads to be introduced into the helicopter rotor wash and to be carried onto the helipad. Additionally, wind speeds contacting the surface of the dust collector were much greater as the helicopter passed directly over it than those introduced to the dust collector located on the adjacent side of the helipad. These velocities may have "cleaned" the filters from dust as the helicopter passed during subsequent landings.

Both the pilot and ground crew indicated that helipad 13 produced the least dust during the landings. Helipads 6 and 7 were similar in performance and were rated as being worse than 13 but still very effective. Helipad 12 was considered dusty but better than the untreated helipad.

The 150- by 150-ft helipads treated an area large enough for adequate reduction in dust during the CH-53 landings. The forward approaches did cause large dust clouds to form in front of the aircraft, but these clouds dissipated once the aircraft was located over treated soil.

CH-46 rotary wing aircraft testing

The evaluation of dust palliatives for the CH-46 aircraft took place from 0900 to 1000 on 6 October 2005. The aircraft landed on the untreated helipad first to allow the pilot and ground crew to observe the native conditions before comparing product performance. Pilot rankings and dust collection data are located in Table 13. Photos 31 through 37 illustrate the relative effectiveness of each palliative.

Table 13
CH-46 Dust Collection Data

Product	Helipad	Initial Filter Weight (g)		Final Filter Weight (g)		Dust Collected (g)			Pilot Ranking
		Southeast	Southwest	Southeast	Southwest	Southeast	Southwest	Total	
Durasoil®	13	13.248	12.970	13.831	13.648	0.583	0.678	1.261	1
Envirokleen® (0.36 gsy)	7	13.392	13.216	13.969	14.895	0.577	1.679	2.256	2
Envirokleen® (0.60 gsy)	6	13.091	13.039	14.121	13.808	1.030	0.769	1.799	3
Surtac®	5	12.888	13.356	14.277	15.059	1.389	1.703	3.092	4
Dust Fyghter®	12	12.213	12.168	14.182	14.722	1.969	2.554	4.523	5
Helotron	10	13.276	13.516	14.177	14.433	0.901	0.917	1.818	6
Control	15	13.609	12.607	15.867	15.658	2.258	3.051	5.309	7

Dust collection data indicate that all but one of the products were effective and reduced dust by approximately 40 to 80 percent. The only product that generated dust concentrations similar to the control helipad was Dust Fyghter®. This product relies on retention of ambient moisture as its mechanism of dust suppression. The low humidity and high temperatures in this climate had reduced its effectiveness to unacceptable levels during this evaluation.

The three synthetic fluids performed excellently during this phase of the evaluation, with Durasoil® preventing the most dust. Data also indicate Helotron performed similarly to the synthetic fluids. These data contrast observations made by the pilot. After the initial “dust off” landing, the Helotron helipad began to produce significant quantities of FOD near the center of the helipad (Photo 38). The pilot most likely noted poor performance from the risk of damage to the aircraft. Meanwhile, areas located near the dust collectors were still covered by a film of bound soil particles. Dust concentrations in the air were minimal at these locations, indicating excellent performance as detected by the dust collection system. Due to perceived FOD potential, the lower application rate of Helotron (helipad 11) was not tested to minimize risk to the aircraft.

A significant difference in the data from the two locations of the dust collectors was not noted during CH-46 landings. The dust collectors on the southwest side of the helipad generally collected more dust than those on the southeast side. However, trends within the data are very similar. The greater quantities collected on the southwest side of the helipads are most likely due to the approach of the aircraft and its disturbance of some of the untreated soil adjacent to the helipad.

AH-1 rotary wing aircraft testing

The evaluation of dust palliatives for the AH-1 aircraft took place from 1415 to 1515 on 7 October 2005. The untreated helipad (No. 15) was tested first to allow the pilot and ground crew to observe the native conditions before comparing product performance. Pilot rankings and dust collection data are located in Table 14. Photos 39 through 44 illustrate the relative performance of each helipad.

Table 14
AH-1 Dust Collection Data

Product	Helipad	Initial Filter Weight (g)		Final Filter Weight (g)		Dust Collected (g)			Pilot Ranking
		Southeast	Southwest	Southeast	Southwest	Southeast	Southwest	Total	
Durasoil® (0.36 gsy)	13	11.972	12.475	12.403	13.764	0.431	1.289	1.720	1
Envirokleen® (0.36 gsy)	7	12.674	12.091	14.360	15.137	1.686	3.226	4.912	2
Envirokleen® (0.60 gsy)	6	12.900	12.860	13.552	17.741	0.652	4.881	5.533	3
Surtac® (0.60 gsy)	5	13.407	13.230	14.001	15.224	0.594	1.994	2.588	4
Surtac® (0.36 gsy)	14	13.582	13.387	14.689	14.783	1.107	1.396	2.503	5
Control	15	12.476	12.863	25.323	18.795	12.847	5.932	18.779	6

Data from the evaluation of dust palliatives with the AH-1 aircraft indicate excellent performance from all tested products. At least a 70 percent reduction in dust was observed on all helipads as indicated by the dust collection data. Collectors on the southeast sides of the helipads retained less soil weight than the collectors on the southwest sides for each of the treated helipads. Helipad 13 produced the lowest quantity of dust and was also rated as the best product. Other data are not consistent with the viewpoint of the pilot. Helipads 6 and 7 were rated higher than 5 and 14, but had higher quantities of dust. It was observed, however, that the particle size of the soil retained on helipads 6 and 7 was larger than that on helipads 5 and 14. While more soil may have been suspended in the air at the level of the dust collectors, the larger grains would not remain airborne as long as the finer particles and would appear to the pilot as being less dusty.

All data indicate helipad 13 being the most effective product for dust mitigation. Very little visible dust was observed during the landing sequence on this helipad. Helipads 7 and 6 were observed to perform similarly to 13 but slightly worse. Little difference was noted in these two helipads that were treated with different rates of the same palliative. Helipads 5 and 14 also contained the same product at different application rates. The pilot perceived these helipads as being dustier than helipads 7 and 6. The lighter application on helipad 14 was more susceptible to FOD generation.

5 Data Analyses

Data from evaluations with each type of aircraft were compiled and analyzed along with soil data to determine the effectiveness of both dust palliatives and application rates for reducing dust during rotary wing aircraft landings.

Soil Data Analyses

Characterization of the native soil before and after palliative application allowed researchers to identify mechanisms by which dust mitigation was achieved and to evaluate the effectiveness of these mechanisms in relation to performance during aircraft landings. Measuring the characteristics of the soil at each location ensures that palliatives can be fairly evaluated based on their performance and not on potential variation of soil properties. This information allows researchers to speculate on sources for poor performance and to recommend alterations that may improve current techniques.

DCP data were used to identify the soil strength at depths from 0.5 to 2 ft. Surface strengths cannot be identified because significant confinement of the soil around the penetrating rod does not exist. Data from the DCP suggest soil strengths below the surface are approximately an 8 CBR for all helipads.

Nuclear density and moisture measurements were recorded for each site to monitor any changes in the consolidation or moisture content of the soil among locations or with time. No significant differences were observed that would impact results of the demonstration.

Geonor vane shear data do show differences in the near surface strength of the soil after applying different types of dust palliatives. Some types of chemicals (synthetic fluids and chloride salt) had little effect on the shear strength. They provide little adhesion of soil grains and promote dust mitigation by encapsulating soil particles and providing enough weight to keep them from becoming suspended in the air. Other chemicals (polymer emulsions, powdered polymer, and emulsified rubber) formed a bonded matrix of soil grains that greatly increased the shear resistance at the surface. The magnitude of this resistance was proportional to the application rate and related to the stiffness of the binding agent. Shear strength data did not provide an accurate indicator of product performance during aircraft landings. It only indicated the mechanism by which dust mitigation was obtained.

Dust Collection Data Analyses

Table 15 provides a summary of the dust collection system data for each aircraft and testing location. The data show that the synthetic fluids were very effective at reducing the amount of dust generated during landings. The polysaccharide product also provided significant mitigation of dust. The film forming products (polymer emulsion, powdered polymer, emulsified rubber) gave good results but had limited landings due to the risk of FOD damage.

Table 15
Dust Collection Data Summary

Product	Helipad	Southeast[1]				Southwest[2]				Total			
		UH-1	CH-53	CH-46	AH-1	UH-1	CH-53	CH-46	AH-1	UH-1	CH-53	CH-46	AH-1
Durasoil® (0.36)	13		3.131	0.583	0.431		1.666	0.678	1.289		4.797	1.261	1.720
Envirokleen® (0.60)	6	0.971	1.233	1.030	0.652	0.260	2.695	0.769	4.881	1.231	3.928	1.799	5.533
Envirokleen® (0.36)	7		21.228*	0.577	1.686		2.695	1.679	3.226		23.923*	2.256	4.912
Surtac® (0.60)	5	0.674		1.389	0.594	0.307		1.703	1.994	0.981		3.092	2.588
Surtac® (0.36)	14				1.107				1.396				2.503
Dust Fyghter® (0.60)	12	0.707	1.267	1.969		0.305	5.665	2.554		1.012	6.932	4.523	
Soil~Sement® (0.60)	3	0.996				0.780				1.776			
Powdered Soiltac® (0.60)	2	0.574				0.181				0.755			
Soiltac® (0.60)	4	0.924				10.965*				11.889 *			
Helotron (0.60)	10			0.901				0.917					1.818
Control	15	6.707	4.156	2.258	12.847	2.265	11.040	3.051	5.932	8.972	15.196	5.309	18.779

[1] Dust collector on northwest side during UH-1 landings (approach side).
[2] Dust collector on northeast side during UH-1 landings.
* Dust collector fell over during landing sequence and provided unrepresentative data.

The UH-1 aircraft appeared to generate the least amount of dust for most of the helipads according to the dust collection data. The CH-53 generated the most dust of any of the aircraft. Data suggest that the CH-46 and AH-1 produced similar quantities of dust. These observations were expected and proportional to the weights of the aircraft and the thrust necessary to lift them from the ground. The weight of the CH-46 is approximately double the weight of the AH-1, but the two rotors provide twice the surface area available for thrust.

The summary of the pilot's rankings of the helipads is given in Table 16. The pilot's viewpoint was considered to give the most accurate perspective on the performance of the dust palliatives. The ground crew was often obscured from evaluating the helipads because of dust clouds generating from the perimeter of the helipads.

Table 16
Summary of Pilot's Ranking

Helipad	Product	UH-1	CH-53	CH-46	AH-1
13	Durasoil® (0.36)		1	1	1
7	Envirokleen® (0.36)		2	2	2
6	Envirokleen® (0.60)	1	3	3	3
5	Surtac® (0.60)	3		4	4
14	Surtac® (0.36)				5
12	Dust Fyghter® (0.60)	2	4	5	
3	Soil~Sement® (0.60)	4			
2	Powdered Soiltac® (0.60)	5			
4	Soiltac® (0.60)	6			
10	Helotron (0.60)			6	
15	Control	7	5	7	6

Helipad 13 was consistently rated the best product during all landing sequences by the pilot and ground crew. Helipads 7 and 6 were considered nearly equivalent in effectiveness, but they never were rated higher than helipad 13. Helipad 5 was also considered to effectively reduce dust consistently throughout the evaluation period. Helipad 12 performed well during the first day of landings, but failed to be effective with other aircraft. The polymer emulsions, the powdered polymer, and the emulsified rubber were rated poorly because of the generation of FOD as pieces of the surface crust began to break from the ground.

Discussion

Dust palliatives

Materials selected for mitigating dust on helipads must create an area with minimal visibility loss without introducing potential damage to the aircraft. These materials must also produce desirable results utilizing minimal logistical effort. This evaluation provided data to prescribe recommendations for chemical dust abatement for helipads.

The synthetic fluids were consistently the most effective materials for reducing dust for all aircraft. In addition to dust reduction, the soil treated with the synthetic fluids remained soft and unbound. No potential for FOD was observed with these products. The application rate for the two helipads rated best was 0.36 gsy. This rate required 600 gal less liquid than the application rate for other products that did not perform as well. This reduction in rate can prevent the unnecessary transportation of over 5,000 lb of product for a 150- by 150-ft helipad, thereby reducing the logistical requirements for dust abatement. The synthetic fluids did not reveal any deterioration with accumulated landings, but any problematic areas could be easily maintained by applying additional palliative to needed areas. This maintenance technique would not be acceptable for film-forming products such as polymer emulsions or others. The synthetic fluids are easy to use and require no mixing of multiple components or dilution with prescribed ratios of water and product. These materials are recommended for use on helipads because of the benefits described above.

The polysaccharide product gave marginal to good performance during the evaluations. It generally mitigated significant quantities of dust but did have some visibility problems during landings. The product became very brittle when it dried. The binding ability of the polysaccharide was very weak and broke under foot traffic. FOD generated during landings consisted of small pieces (less than 10 sq in.) but did exist. Exposure to moisture prevented this problem and made the treated soil soft and reworkable. This observation was made one morning after a night with relatively high humidity in the air. The brittle nature of the treated soil was alleviated and foot traffic only caused depressions in the soil. The durability of the polysaccharide is considered to be minimal in climates with frequent precipitation because it is a water-soluble material and may leach from the soil.

The chloride salt was not effective at mitigating dust for sustained periods of time. The product provided excellent dust abatement after placement, but the performance deteriorated rapidly. The deliquescent material was unable to retain moisture in the climate that was present. Upon drying the chloride salt was unable to mitigate dust on the helipad. This product would only be recommended for helipads with lifespans less than 2 days.

The polymer emulsions provided excellent adhesion to soil grains and provided a strong network of polymer and soil on the ground surface of the helipads. However, lack of penetration of the emulsions resulted in a thin surface crust that was easily broken and provided a focal point for FOD generation. Large sheets of bonded soil (greater than 1 sq ft) pose risk to the aircraft if they are introduced into the rotor wash. Quantities of diluted polymer emulsions would have to exceed 1 gsy in order to provide dust abatement and eliminate FOD potential under soil conditions present at the testing site. In addition, techniques for achieving greater penetration of these products are required. Soil surfaces with a higher bearing capacity would be necessary to obtain favorable results with the quantities of product used.

The powdered polymer performed similarly to the polymer emulsions. This product appeared to have a more flexible surface crust that caused it to break into larger sections. It also achieved less penetration than the polymer emulsions due to its higher viscosity. The dust mitigation ability of the product was excellent, but greater penetration would be necessary to eliminate FOD potential.

The emulsified rubber also exhibited performance similar to the polymer emulsions. Its performance as a dust abatement product was excellent, but the lack of penetration and subsequent FOD generation create concern for use on helipads.

In general, emulsified products have inherent limitations that should be considered during procurement, transportation, and use. These materials should not be exposed to temperatures below 32 ^{o}F (0 C) or above 140 ^{o}F (60 C). They should be kept in sealed containers to prevent exposure to air, thus reducing the potential for bacterial contamination. Storage containers should not be exposed to UV radiation for prolonged periods of time. The shelf life of emulsions should be considered to be less than two years.

Application equipment

The hydroseeder provided an efficient and effective means to distribute dust palliatives on helipads. Neither machine used during the evaluation could cover the entire area of the 150- by 150-ft helipad from a single location using the tower gun. However, delivery of the product proceeded with little time and effort. Applications with the tower gun were faster and required fewer people than applications using the hand-held hose. The tower gun appeared to provide less consistent distribution of product, but the coverage obtained using the tower gun seemed to be sufficient with operator training. Selecting hydroseeder tank capacities that match the liquid requirements for the treated area will greatly reduce the time required to complete the application process. The transportation and filling time necessary to use multiple fillings dominates the total application time. Helipads requiring 0.36 gsy (900 gal) could be completed in about 30 min including filling, transportation, and spraying times.

The hydroseeder operators were asked to identify limitations of the respective equipment in order to develop specifications for the U.S. Marine Corps. The following text provides the information resulting from the field exercise.

a. *Limitations of the Easy Lawn® C95.*

    (1) Machine requires external pump to transfer liquids. It cannot pump liquids from the shipping totes to the distribution tank.

    (2) The hitch on the machine will not connect to the MTVR for towing. An adaptation had to be made to the hitch for towing.

b. *Limitations of the Turfmaker® 800.*

    (1) The spray nozzles connected to the outlet pipe by metal threads. Connecting the nozzles was not fast enough, and the threads could become clogged with polymer. Quick-connect nozzles should be placed on the tower gun and hand-held hose.

    (2) The tower gun would only rotate approximately 60 deg from the rear of the hydroseeder. Spraying liquids in the direction perpendicular to the length of the machine was not possible. A greater swivel range is desired.

    (3) The platform where the operator stands to control the tower gun was too small. Mobility was limited and performing all necessary tasks was difficult from the position.

(4) The clutch for turning the pump on and off was difficult to operate.

(5) The throttle for the engine was difficult to control. It was oversensitive and made the application hard to control.

(6) No variable speed on mechanical agitation. Agitator caused polymer emulsions to foam excessively from high turbulence.

(7) The flexible hose should be replaced by a more rigid hose. The flexible hose was more difficult to carry and sometimes developed kinks. Once the hose was filled with liquid, the application crew noticed no difference in weight or ability to transport. A notable vibration with the flexible hose was uncomfortable during application.

(8) The hand held hose could not remain connected to the machine during unrolling or recovery. The entire length of hose had to be removed and then connected to the machine by threaded metal. The hose should be changed to remain connected to the hydroseeder.

(9) The machine did not have an electric reel to retrieve the hose upon completion of spraying. Manually recovering the hose requires more effort and time.

(10) The top of the tank was not sealed. Liquid spilled from the tank during transportation.

(11) The drain valve cover came loose during spraying on one of the helipads, losing some product. The cover should be more secure.

(12) The machine had no storage compartment for tools/accessories.

Each of these limitations hindered operation of the respective machine and should be addressed prior to procurement. Additional specifications for machine performance are listed in Table 17. These recommendations were developed as a result of a field test taking place in January 2004.

Table 17
Minimum Specifications for Dust Palliative Distribution System

Tank	Metal (Not Plastic) 1200-gal capacity for Skid Mounted Systems 1200-gal capacity for Towed Systems Mechanical Agitator variable speed reversible Valve-Control Liquid Re-circulation
Engine	Diesel, 33.5 hp, Fuel capacity: 15 gal
Pump	Centrifugal, 170 gpm at 100 psi
Gower Gun	Minimum Spray Distance of 150 ft Nozzles-Set of 4: 2 long distance, 1 wide fan, 1 narrow fan
Spray Hose	200 ft, 1-1/2 in. rubber hose for durability Nozzles-Set of 4: 2 long distance, 1 wide fan, 1 narrow fan
Distributor Bar	Minimum of 2-in. line with 4 sets of 5 wide-fan nozzles - 1 set of nozzles with minimum 10 gpm at 40 psi - 1 set of nozzles with minimum 20 gpm at 40 psi - 1 set of nozzles with minimum 30 gpm at 40 psi - 1 set of nozzles with minimum 40 gpm at 40 psi Adjustable Bar height from 18 to 36 in.
Trailer (Towed System)	Tandem axles with sufficient load rating Electric brakes on both axles 24-volt compatible light/brake connectors 10- cu ft storage box Tires - Flotation tires, load range E
Hitch	Heavy duty hitch eye or 2-5/16-in. ball Adjustable Hitch Height: 12 to 40 in.
Empty Weight	6,000 lb max
Working Weight	14,200 lb max
Overall Dimensions	Length - 16 ft 2 in.; Width - 7 ft 1 in.; Height - 9 ft (top of tower gun) The tower gun and railing must be detachable for achieving a maximum shipping height of 78 in.

6 Conclusions and Recommendations

The ERDC was tasked by the MCSC to develop dust control systems for helipads at Forward Area Arming and Refueling Points. The project consisted of a field evaluation of commercially available dust palliatives and application equipment near the Auxiliary II paved landing zone south of MCAS, Yuma, AZ. Fifteen helipads were constructed using commercially available dust palliatives placed with various construction equipment and techniques. Helipads were subjected to landings with UH-1, CH-53, CH-46, and AH-1 rotary wing aircraft to evaluate the effectiveness of the dust palliatives. Ratings were assigned according to the ability of the product to reduce dust without potential for FOD damage. Conclusions and recommendations as a result of this evaluation are listed below.

Conclusions

The following conclusions were derived from the application and testing of selected palliatives from September to October 2005:

a. Mobility was limited on the soft sand for several pieces of equipment. The motor grader had difficulty in clearing the vegetation from the site because of poor traction. The High Mobility Multi-Wheeled Vehicle was unable to tow the hydroseeder at the site. The MTVR was suitable for pulling the hydroseeder, but the hydroseeder did not have enough ground clearance to prevent dragging loose soil.

b. Both of the hydroseeders used at the site provided excellent mixing of dust palliatives and dilution water by their respective mechanical agitation system.

c. Both hydroseeders provided two methods of applying liquid dust palliatives: a tower gun and a hand held hose.

d. A 150-ft by 150-ft helipad cannot be treated with dust palliatives by either of the hydroseeders tested from a single location using the tower gun. The tower gun will spray distances of approximately 130 ft.

e. Each hydroseeder was capable of rapidly applying dust palliatives to the helipads. This type of equipment was very effective and could complete the process in as little as 20 to 30 min for a 150-ft by 150-ft helipad.

f. Skid-mounted hydroseeders are easier to transport with the MTVR because of low ground clearance on the trailer-mounted hydroseeders.

g. All of the dust palliatives could be sprayed with the hydroseeder. None had viscosities high enough to cause application problems.

h. Powdered Soiltac® immediately dissolved in water when placed in the tank of the hydroseeder. No problematic increases in the viscosity of the solution were noted.

i. The synthetic fluids were very effective at both 0.36 gsy and 0.60 gsy application rates for mitigating dust on helipads.

j. The synthetic fluids did not reach full penetration depth within the first day after application. These materials require several days to reach their maximum potential for dust abatement.

k. The polymer emulsions did not reach sufficient penetration depths when applied at a 3:1 dilution ratio and a 0.60 gsy application rate. Lower application rates were also deemed unacceptable.

l. Penetration depths of less than 1 in. were unable to resist crust breakup during helicopter landings. Broken layers of thin surface crust presents potential danger for FOD to the aircraft.

m. Application rates of over 1 gsy will be required when using polymer emulsions for dust abatement on helipads.

n. The emulsified rubber performed similarly to the polymer emulsions. It would not be recommended at an application rate lower then 1 gsy for reasons associated with polymer emulsions.

o. The chloride salt did not provide sufficient dust abatement during the evaluation. It was initially effective, but only for the first day of helicopter landings. The chloride salt is unable to retain moisture at humidity levels and temperatures present during the exercise.

p. The polysaccharide performed adequately during the evaluation. It was unable to resist breakup during landings and could pose some FOD problems.

q. The powdered polymer performed similarly to the polymer emulsions. It would have to be applied at rates greater than 1 gsy to provide acceptable penetration and dust abatement.

r. Emulsified products may have limited stability as evidenced by the coagulation of the Envirotac II® product. Destabilized emulsions cannot be used for dust control and must be discarded in an appropriate manner.

s. An admixing procedure may provide adequate product distribution for a suitable crust thickness at application rates less than 1 gsy, but admix procedures would greatly increase manpower, equipment, and time requirements.

Recommendations

The following recommendations are given based upon the results of the field tests:

a. Hydroseeders are recommended for distributing dust palliatives on helipads. Limitations of the system noted in the text should be addressed when selecting systems for U.S. Marine Corps use.

b. Hydroseeders should have multiple application methods for distributing products. These should include and not be limited to a tower gun and hand-held hose. A rear distribution bar may also be beneficial for roads and airfields.

c. Machine specifications for hydroseeders should meet or exceed the listed requirements in Table 17.

d. Either of the synthetic fluids evaluated are recommended for use on helipads at an application rate of 0.36 gsy as a result of field data and observations made during the field evaluation. These materials are to be placed "neat" onto the soil using a topical application with no water for dilution.

e. Helicopter landings can proceed immediately after applying the synthetic fluids. However, it is recommended that they be applied at least 2 days in advance of landings for optimal performance.

f. Deteriorated areas on helipads treated with synthetic fluids should be repaired by reapplying the product at an application rate of 0.36 gsy to any areas of exposed untreated soil.

g. Polymer emulsions and emulsified rubber should not be used for mitigating dust on helipads using less than 1 gsy of a 3:1 dilution of water and dust palliative. Application rates lower than 1 gsy will potentially produce FOD damage to the aircraft upon landing.

h. Polysaccharides should be used for dust mitigation at a dilution ratio of 3:1 and an application rate of no less than 0.60 gsy. Higher application rates (1 gsy) may be necessary to improve performance.

i. Chloride salts are not recommended for dust abatement on helipads in arid environments.

j. Powdered polymer may be used for dust abatement at 1.4 lb powder per gallon of water. The application rate for this product should be greater than 1 gsy.

k. Powdered polymer only refers to Powdered Soiltac® evaluated during the field exercise. Many powdered polymers have a different chemical composition and are not recommended for use. Additionally, some types of powdered polymers cause extremely high viscosities to develop in the solution. These types of materials will have difficulty spraying from an application device.

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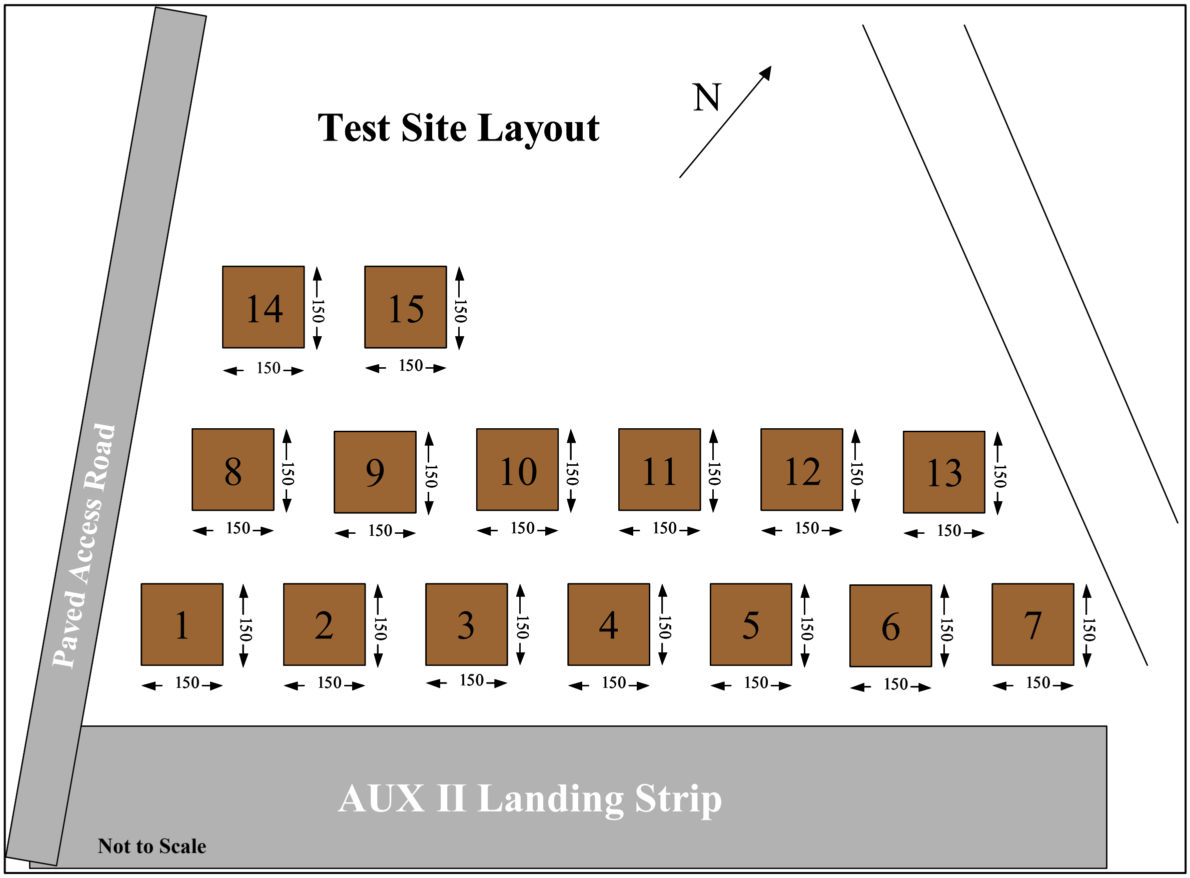

Figure 1. Layout of test sections

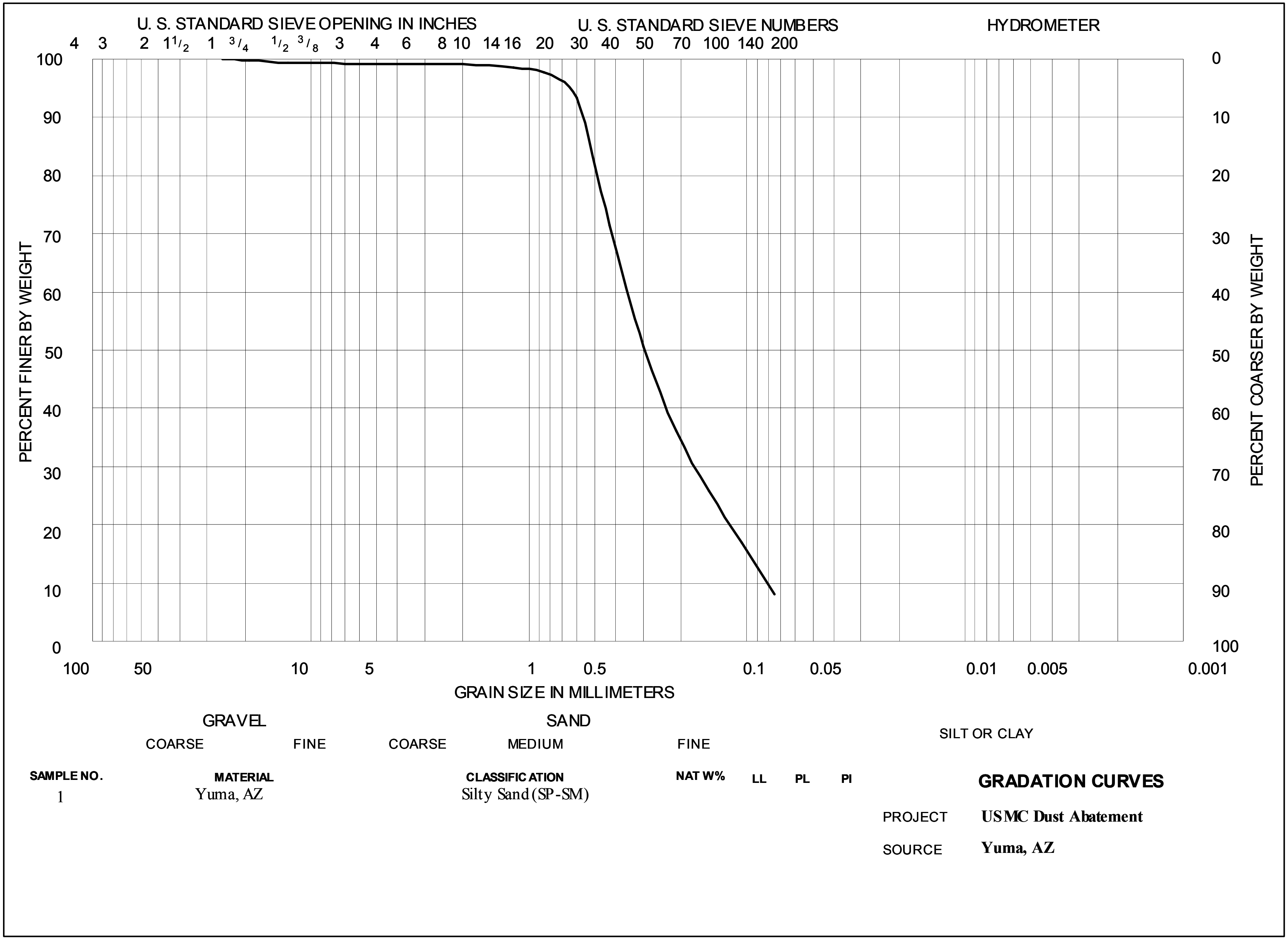

Figure 2. Grain size distribution for soil at testing location

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Photo 2. John Deere® 544J bucket loader back blading soil prior to palliative application

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Photo 4. Adapted hitch height on Easy Lawn® C95 hydroseeder to connect to MTVR

Photo 5. Turfmaker® 800 hydroseeder on bed of MTVR

Photo 6. Troxler® 3430 nuclear density gauge for measuring soil density and moisture content

Photo 7. Measuring near surface soil shear strength with Geonor® H60 device

Photo 8. Using the Dynamic Cone Penetrometer (DCP) to measure soil strength

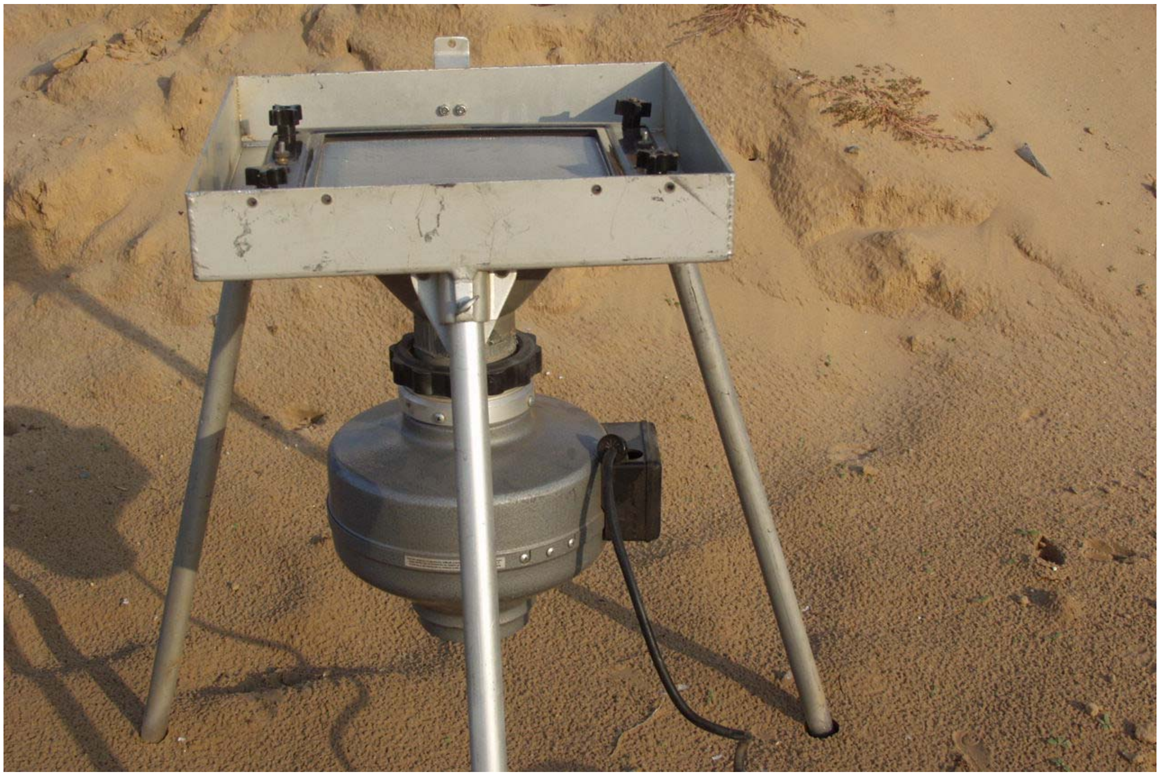

Photo 9. Dust collection system

Photo 10. Unloading 275 gallon totes of dust palliatives using Caterpillar® TH460B forklift

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Photo 17. UH-1 landing on helipad 3 (Soil~Sement®, 0.6 gsy)

Photo 18. UH-1 landing on helipad 12 (Dust Fyghter®, 0.6 gsy)

Photo 19. UH-1 landing on helipad 2 (Powdered Soiltac®, 0.6 gsy)

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Photo 21. UH-1 landing on helipad 4 (Soiltac®, 0.6 gsy)

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Photo 27. CH-53 landing on helipad 7 (Envirokleen®, 0.36 gsy)

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Photo 29. CH-53 landing on helipad 6 (Envirokleen®, 0.6 gsy)

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Photo 31. CH-46 landing on untreated helipad

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Photo 33. CH-46 landing on helipad 7 (Envirokleen®, 0.36 gsy)

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Photo 36. CH-46 landing on helipad 10 (Helotron®, 0.6 gsy)

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Photo 39. AH-1 landing on untreated helipad

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Photo 41. AH-1 landing on helipad 7 (Envirokleen®, 0.6 gsy)

Photo 42. AH-1 landing on helipad 5 (Surtac®, 0.6 gsy)

Photo 43. AH-1 landing on helipad 6 (Envirokleen®, 0.6 gsy)

Photo 44. AH-1 landing on helipad 13 (Surtac®, 0.36 gsy)

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14. ABSTRACT

The ERDC was tasked by the U.S. Marine Corps Systems Command to develop expedient dust control systems for helipads for use in constructing and maintaining Forward Area Refueling Points (FARPs). The project consisted of evaluating various chemical dust palliatives and application procedures during field tests. The products of this effort include equipment recommendations, palliative recommendations, and complete application guidance. Seventeen helipads were constructed at Marine Corps Air Station Yuma, AZ, using commercial palliatives for dust abatement. Each chemical was applied using a topical (spray-on) treatment. Each helipad was subjected to multiple landings of UH-1, CH-53, CH-46, and AH-1 aircraft. The chemicals were evaluated on their ability to control dust and prevent Foreign Object Damage (FOD). Each evaluation consisted of dust particle collection and soil property measurements. Pertinent conclusions from the testing conducted are noted, and recommendations for selecting dust abatement methods and materials are provided.

15. SUBJECT TERMS

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